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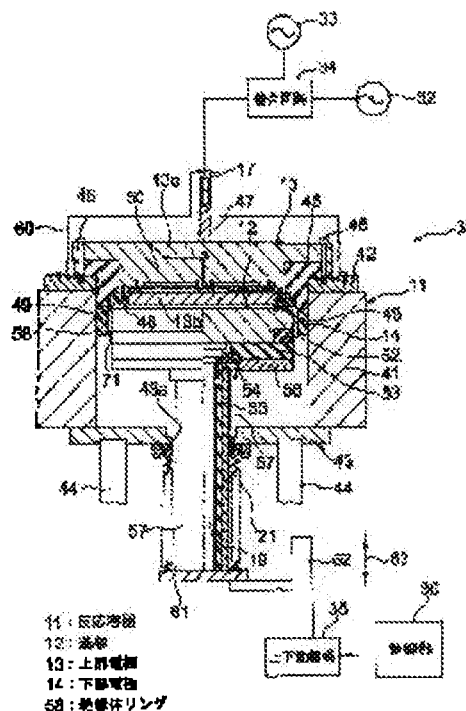
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## (54) PLASMA TREATMENT EQUIPMENT AND ITS CLEANING METHOD

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a plasma treatment equipment and a method for cleaning it by which the amount of exhaust gas is reduced by improving the usability of cleaning gas, its productivity is improved, the amount of usage of process gas is reduced and the process cost is reduced, and which help solve the problem of global warming and reduce the adhesion of film to the inner surface of its chamber.

**SOLUTION:** The plasma treatment equipment 31 is provided with an upper electrode 13 and a lower electrode 14 in its reaction case 11. Its first electrode is supplied with VHF band waves from a VHF band power source 32, and its lower electrode carries a substrate 12 and is moved by a vertically moving mechanism 35. The plasma treatment equipment 31 also has a cleaning controller 36 by which the lower electrode 14 is moved by the vertically moving mechanism 35 for reducing the space between the upper electrode 13 and the lower electrode 14, and forming a narrow space; and starts a cleaning process by specified high-density plasma in the narrow space after forming films on the substrate 12. A step cleaning is performed in the cleaning process.



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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Field of the Invention]In this invention, the utilization efficiency of cleaning gas is especially raised about a plasma treatment apparatus and a cleaning method for the same.

Therefore, it is related with a large-sized plasma-CVD processing unit with the cleaning function which reduces an exhaust gas amount, and the process of the cleaning.

[0002]

[Description of the Prior Art]For example, in the conventional plasma-CVD processing unit, based on the demand from a membrane formation process, the device is designed chiefly, and the cleaning in the film forming chamber of a device has only been added as tuning of a membrane formation process. It has the parallel plate type electrode structure which changes from an upper electrode and a lower electrode to the inside of a film forming chamber, electric power is supplied to an upper electrode etc. in high frequency, and he causes discharge with the energy, and was trying to generate plasma. The high frequency of the 13.56-MHz HF-bands region appointed in the industrial band as the above-mentioned high frequency was used. The above-mentioned lower electrode functions as a substrate holder, and the substrate which is a candidate for membrane formation is carried on it. Usually, the lower electrode was attached with the fixed structure. Furthermore, usually the lower electrode was made from the aluminum alloy, or surface alumite treatment of the part was carried out, and it was made, on the other hand the above-mentioned upper electrode is made from pure aluminium.

[0003]JP,10-237657,A can be mentioned as literature which indicates conventional technology. In the plasma treatment apparatus indicated by this gazette. The showerhead (21) in which high frequency is supplied in a reaction vessel (10: number used in a gazette), The susceptor (2) which a substrate (70) is carried and goes up and down by a substrate lift style (50) is provided, and the structure where a showerhead is fixed via an insulator (41) on a chamber (31) is shown. The insulator (41) is formed in order to insulate a chamber (31) with a showerhead (21) electrically.

[0004]

[Problem(s) to be Solved by the Invention]In recent years, the device concept for carrying out "reducing a discharge by making utilization efficiency of cleaning gas high" is considered previously, and the large-sized

plasma-CVD processing unit developed is requiring the device design which accepts the demand from a membrane formation process into the concept. Therefore, the cleaning process in a membrane formation chamber cannot be positioned like the former as an additional process in a film forming chamber which carries out a membrane formation process pair.

[0005]In the above-mentioned plasma-CVD processing unit etc., although there is an advantage that using the above-mentioned HF-bands high frequency uses an industrial band, it is difficult to generate high-density plasma with the device which has parallel plate type electrode structure. Even if this is a membrane formation process and it is a cleaning process, it is the same.

[0006]According to the conventional plasma-CVD processing unit mentioned above, the density of the plasma generated between an upper electrode and a lower electrode is low, and since bias voltage is not impressed, either, the construction material of an upper electrode or a lower electrode is as above-mentioned, and is enough. However, when the degree of nectar of plasma is made high and high bias starts, it becomes insufficient, after a membrane formation process, clean GUPUROSESU, or a chamber maintains.

[0007]When generating plasma by high density and performing membrane formation by plasma CVD, an upper electrode, If the inner surface of a chamber is exposed to the space of the plasma production and plasma treatment which are formed between the lower electrodes in the state where this was made to approach, and are formed as a narrow space, A film adheres to the exposed surface concerned easily, cleaning becomes troublesome, and the fault that cleaning cannot be made efficient is produced.

[0008]The purpose of this invention is to solve the above-mentioned technical problem, for example, it is a large-sized plasma-CVD processing unit etc., An exhaust gas amount is reduced by raising the utilization efficiency of cleaning gas, It is in providing a plasma treatment apparatus which raises cleaning speed, makes productivity good, reduces the amount of the process gas used, reduces process cost, is useful for solution of a global warming issue, and planned to reduce film adhesion in the inner surface of a chamber, and a cleaning method for the same.

[0009]

[Means for Solving the Problem and its Function]A plasma treatment apparatus concerning this invention and its cleaning device are constituted as follows to achieve the above objects.

[0010]The 1st plasma treatment apparatus (it corresponds to claim 1), Have electrode structure which comprises the 1st electrode and the 2nd electrode in a chamber which may be decompressed by vacuum, and high frequency from a VHF band RF generator is supplied to the 1st electrode, and. The 2nd electrode is the plasma treatment apparatus which has a substrate mount part and was moved by moving mechanism (vertical movement mechanism), Move the 2nd electrode according to a moving mechanism, narrow a crevice between the 1st electrode and the 2nd electrode, and a narrow space is formed, Form membranes to a substrate of predetermined low density, and in this narrow space In and the case of a cleaning process after membrane formation and substrate taking out. The 2nd electrode is moved according to a moving mechanism, a crevice between the 1st electrode and the 2nd electrode is narrowed, and a narrow space is formed, and it is constituted so that it may have a cleaning control section which starts cleaning with high-density predetermined plasma in this narrow space. Usually, the 1st electrode is an upper electrode and the 2nd electrode is a lower electrode. A lower electrode is made to go up and down, where a substrate is

carried.

[0011]In the 1st plasma treatment apparatus of the above, high density plasma of high power is made to generate in a narrow space in the state where the 1st electrode and the 2nd electrode approached, and it has the composition which starts plasma cleaning.

[0012]In the above-mentioned plasma treatment apparatus, it is preferably characterized by high density of plasma being more than one  $10^{11}\text{-cm}^{-3}$  ( $10^{11}\text{cm}^{-3}$ ) (it corresponds to claim 2).

[0013]In the above-mentioned plasma treatment apparatus, preferably, a wall part of a chamber from the principal surface of the 1st electrode to at least 3 cm is covered in an insulating material ring, and a narrow path field of 5 mm or less is formed for an interval between an insulating material ring and a flank of the 2nd electrode (it corresponds to claim 3).

[0014]In the above-mentioned plasma treatment apparatus, an insulating material ring is preferably made from alumite (it corresponds to claim 4).

[0015]In the above-mentioned plasma treatment apparatus, it is preferably superimposed on a low frequency wave from LF belt low frequency power source to high frequency from a VHF band RF generator (it corresponds to claim 5).

[0016]In the above-mentioned plasma treatment apparatus, both the 1st electrode and the 2nd electrode are preferably made from pure aluminium more than purity  $10^{-4}$  ( $10^{-4}$ ) (it corresponds to claim 6).

[0017]A cleaning method (it corresponds to claim 7) of a plasma treatment apparatus concerning this invention, It is a cleaning method which removes with plasma a film which adhered to an inside of a chamber after growing up an insulator layer by plasma CVD on a substrate and taking out a substrate after that, A cleaning process comprises two or more steps, and the 1st step, An interval of the 1st electrode and the 2nd electrode is a narrow space, and it is carried out in the state of high density plasma formed in a high power field of VHF band high frequency, and the 2nd step, A wall part of a chamber from the principal surface of the 1st electrode to the prescribed distance lower drops the 2nd electrode to the undersurface of a wrap insulating material ring, It is carried out only by high density plasma formed in a high power field of VHF band high frequency by this state, and the 3rd step drops the 2nd electrode to the lowest, and is characterized by what cleaning is performed for with plasma formed in a low-electric-power field of VHF band high frequency.

[0018]In the above-mentioned cleaning method, a narrow space formed between the 1st electrode and the 2nd electrode is preferably formed at intervals of 1-2 cm (it corresponds to claim 8).

[0019]In the above-mentioned cleaning method, preferably, It is characterized by density of high density plasma in the 1st step and the 2nd step being about  $10^{11}\text{-cm}^{-3}$ , and density of low density plasma in the 3rd step being about  $10^{10}\text{-cm}^{-3}$  (it corresponds to claim 9).

[0020]In the above-mentioned cleaning method, preferably, it is superimposed on LF belt low frequency wave from LF belt low frequency power source to high frequency from a VHF band RF generator, and plasma formation of the 1st step and the 2nd step of a cleaning process is performed (it corresponds to claim 10).

[0021]

[Embodiment of the Invention]Below, the suitable embodiment of this invention is described based on an

accompanying drawing.

[0022]It is only what was shown roughly to such an extent that this invention can understand and carry out about the composition, the shape, the size, and arrangement relationship which are explained by an embodiment, and it is only illustration about a numerical value and the presentation (construction material) of each composition. Therefore, this invention is not limited to the embodiment described below, and unless it deviates from the range of the technical idea shown in a claim, it can be changed into various gestalten.

[0023]The following explanation gives and explains the example of a large-sized plasma CVD device.

However, this invention is not limited to this and can generally be applied to a plasma treatment apparatus.

[0024]Drawing 1 and drawing 2 are the sectional views showing the internal configuration of a plasma CVD device. This plasma CVD device 31 has the parallel plate type electrode structure which comprises the upper electrode 13 and the lower electrode 14. The upper electrode 13 is an electrode which is superimposed on two kinds of cycles and supplied via the matching circuit 34 from RF generator 32 of VHF band high frequency, and the low frequency power source 33 of LF belt low frequency wave. The lower electrode 14 is an earth electrode which forms the substrate holder stage used as a substrate mount part. The vertical movement mechanism 35 is attached to the lower electrode 14, and the lower electrode 14 is made to go up and down by this vertical movement mechanism 35. The state where the state where drawing 1 has the lower electrode 14 in an upper limit position is shown, and drawing 2 has the lower electrode 14 in a lower limit position is shown.

[0025]In the above, although two electrodes which counter were described as the "upper electrode" and the "lower electrode", what is necessary is just the 1st and the 2nd electrode, and it is not limited to the upper part and the lower part.

[0026]In the example of a graphic display, the reaction vessel 11 which forms a film forming chamber is made from the sealed structure, and it is set up so that an inside may be in a necessary vacua (reduced pressure state). The reaction vessel 11 is made with a metallic material, and has conductivity. The gas introducing mechanism into which the reaction vessel 11 introduces the port which carries in and takes out actually the substrate 12 which is a processing object, the exhaust port which makes an inside a necessary vacua, and the discharge gas which produces discharge, such as the exhaust, is attached. In drawing 1 and drawing 2, since a well-known structure is established about the above-mentioned element, those graphic displays on [ of explanation ] expedient are omitted.

[0027]The reaction vessel 11 comprises the face members 41 of a cylindrical shape, the ceiling member 42, and the bottom material 43. The reaction vessel 11 is grounded and is held at earth potentials. The bottom material 43 is supported with two or more supporting posts 44 supporting the whole reaction vessel 11. An opening is formed in the center of the ceiling member 42, and the upper electrode 13 is attached to this opening with the bolt 46 via the ring shape insulator 45. The upper electrode 13 comprises the upper member 13a and the lower member 13b. The high frequency transmission medium 17 is connected to the connecting end section 47 established in the central part of the upper surface of the upper member 13a. The lower member 13b is being fixed to the undersurface of the upper member 13a on the screw 48. On the screw 48, the insulator 49 of ring shape is simultaneously attached to the undersurface edge part of the lower member 13b of the upper electrode 13. The gas passageway 50 which passes process gas is formed in the space between the upper member 13a and the lower member 13b, and the inside of the upper

member 13a. The graphic display of the gas introducing mechanism for introducing discharge gas into this gas passageway 50 is omitted.

[0028]The upper electrode 13 and the lower electrode 14 make the gestalt of a circular conductive plate fundamental as a whole, at the desirable interval, counter in parallel and are arranged. The interval between the upper electrode 13 and the lower electrode 14 can be arbitrarily changed by changing the height position of the lower electrode 14 according to the above-mentioned vertical movement mechanism 35.

[0029]The upper electrode 13 is connected to RF generator 32 and the low frequency power source 33 via the matching circuit 34. RF generator 32 is a power supply which outputs the electric power of the frequency belonging to a VHF band, and the low frequency power source 33 is a power supply which outputs the electric power of the frequency belonging to LF belt. The high frequency outputted from RF generator 32 is 60 MHz preferably, and the low frequency wave outputted from the low frequency power source 33 is 400 kHz preferably. The cycle outputted from each of the power supplies 32 and 33 is superimposed in the matching circuit 34, and is supplied to the upper electrode 13 in this state. The high frequency and the low frequency wave which are outputted from the power supplies 32 and 33 are supplied to the upper electrode 13 via the cable 17 and the connecting end section 47. The cycle supplied to the upper electrode 13 serves as energy of the main stroke generated in the crevice between the upper electrode 13 and the lower electrode 14.

[0030]Above-mentioned RF generator 32 is the electric power for exciting plasma discharge, and supplies the high power for generating high density plasma, etc. As the density, it is one  $E11\text{-cm}^{-3}$  typically. The low frequency power source 33 is for giving the self bias voltage which determines the collision energy of a positive ion.

[0031]The substrate 12 is carried in the \*\* side of the lower electrode 14. As shown in drawing 2, when the lower electrode 14 descends and it is in a lower limit position, the substrate 12 is supported with the extrusion stick 51, and is in the state where it floated from the mounting surface of the lower electrode 14. Since the lower electrode 14 goes up and moves up when the lower electrode 14 is in an upper limit position, as shown in drawing 1, the substrate 12 is carried in the upper surface of the lower electrode 14 by the contact state.

[0032]When the lower electrode 14 goes up and it is in an upper limit position, the space made from the upper electrode 13 and the lower electrode 14 is narrow in comparison, and a narrow space is formed. At this time, the interval of the undersurface (principal surface) of the upper electrode 13 and the upper surface of the lower electrode 14 is about 1-2 cm typically.

[0033]The 1st insulator 52 of ring shape, the 2nd doughnut disc-like insulator 53, the 3rd insulator 54 of ring shape, and the 4th cylindrical insulator 55 are arranged at the rear-face side of the lower electrode 14. All of the rear face of the lower electrode 14 and the surfaces of the support 19 are covered by the 1st to 4th insulator 52-55. The surface of the further 2nd - the 4th insulator 53-55 is covered with the two conductive members 56 and 57. All the surfaces which expose the insulators 52-55 within the reaction vessel 11 except for the flank peripheral surface of the 1st and the 2nd insulator 52 and 53 are covered with the conductive members 56 and 57.

[0034]In the above-mentioned composition, to the undersurface of the fixed upper electrode 13, the insulator

ring 58 is formed so that the internal surface of the reaction vessel 11 may be typically worn from there with a distance of at least 3 cm in between to a lower part. This insulator ring 58 is made from the construction material like alumite. When the lower electrode 14 is in a maximum position, the distance between the peripheral flank of the lower electrode 14 and the inner surface of the insulator ring 58 is 5 mm or less preferably, and the narrow path (or narrow path field) 71 is formed.

[0035]The support 19 of the lower electrode 14 is a rod-like, and is made from the member which has conductivity. The conductive flange 61 is formed in the lower end of the support 19. The support 19 of the lower electrode 14 and the portion relevant to this are installed in the lower area of the reaction vessel 11 via the opening 43a formed in the center of the bottom material 43. These portions are surrounded by the bellows 21 attached to the undersurface of the bottom material 43 so that the outside of the opening 43a formed in the bottom material 43 might be covered. That is, the cylindrical conductive bellows 21 is formed between the edge and the flange 61 which form the opening 43a. The bellows 21 maintained the sealed state and has connected the edge of the opening 43a, and the edge part of the flange 61.

[0036]Like the above-mentioned, the reaction vessel 11 is grounded and is held at earth potentials. Since it is electrically connected to the reaction vessel 11 via the support 19, the flange 61, and the bellows 21, the lower electrode 14 will be held similarly at earth potentials.

[0037]The above-mentioned flange 61 is attached to the vertical movement mechanism 35 in drawing 1 and drawing 2. According to the vertical movement mechanism 35, the flange 61 can be gone up and down like the arrow 63 along with the inside 62 of a proposal. In connection with the vertical movement of the flange 61, the lower electrode 14 and the structure part relevant to this also move up and down. Since the bellows 21 is structurally elastic, where the above-mentioned sealing nature is held, it expands and contracts. The lower electrode 14 can be made to go up and down based on this structure, thereby, the height position of the substrate 12 is changed, and the interval (distance) of the upper electrode 13 and the lower electrode 14 can be changed, and the size of a crevice can be changed. When causing a main stroke in the crevice between the upper electrode 13 and the lower electrode 14, generating plasma and forming membranes based on a CVD operation to the substrate 12 on the lower electrode 14, the lower electrode 14 is moved to an upper limit position, and distance between the upper electrode 13 and the lower electrode 14 is made small. In the structure by this embodiment, discharge is narrowly stood to the space of an interval in comparison, plasma is generated, and it is made to perform CVD film formation. When the membrane formation to the substrate 12 is completed, according to the vertical movement mechanism 35, the lower electrode 14 is moved below and the interval of the upper electrode 13 and the lower electrode 14 is extended. It becomes possible to exchange the substrate 12 which is a processing object by this.

[0038]Like the above, according to the vertical movement mechanism 35, as shown in drawing 1 and drawing 2, between a lower limit position and an upper limit position, the lower electrode 14 and the structure part relevant to this go up and down. Operation of this vertical movement mechanism 35 is controlled by the control section 36 which comprises a computer. The program for performing a membrane formation process and a cleaning process is stored in the memory attached to the control section 36.

[0039]The covering 60 was fixed to the reaction vessel 11 upper part, and the upper electrode 13 upper part in the reaction vessel 11 is protected.

[0040]In the structure shown in drawing 1 and drawing 2, the structure part by the side of the rear face of the

lower electrode 14, All the outside surfaces of the connection section (support 19) to a ground potential part (flange part) including the rear face of the lower electrode 14 are covered with the insulators 52-55, and the portion of the insulator concerned is altogether covered by the conductive members 56 and 57 except for the flank part. As a result, generating of the discharge by the side of the rear face of the lower electrode 14 which is not desirable can be prevented.

[0041]In the plasma CVD device which has the above-mentioned composition, when the lower electrode 14 goes up and it is usually in an upper limit position, it is a position in which a membrane formation process is performed, and when the lower electrode 14 descends, it is a position to which substrate transportation is carried out. When a membrane formation process is completed, plasma is made from proper timing (after substrate taking out etc.), and cleaning is performed. This cleaning process is step cleaning which consists of two or more steps (stage). In this step cleaning, the lower electrode 14 cleans at the first step by moving to an upper limit position, exciting plasma discharge in a narrow space and generating plasma, such as low density. In the final step of step cleaning, the lower electrode 14 is moved to a lower limit position.

[0042]In the reaction vessel 11 of the large-sized plasma CVD device shown in drawing 1 and drawing 2, the electrode spacing between the upper electrode 13 and the lower electrode 14 has adopted 1 cm and a narrow gap (narrow space) method more preferably 1-2 cm in the case of a membrane formation process. That is, it is constituted so that narrow space membrane formation may be performed. Thus, by narrowing an electrode spacing, it becomes easy to confine plasma in inter-electrode.

[0043]The lower electrode stage 14 in which the substrate 12 is carried, i.e., a lower electrode, is grounded through the structure which bypasses high frequency. This structure is based on the coaxial-type structure which comprises a metal (support 19), an insulator (the 4th insulator 55), and a metal (conductive member 57) as above-mentioned. By the flange 61 of the termination, it is electrically connected and the support 19 and the conductive member 57 are grounded. By establishing this structure, return high frequency does not leak from the lower electrode 14. This is checked also from the electromagnetic-field simulation.

[0044]Like the above, by adopting the above-mentioned structure, it becomes possible to confine plasma in inter-electrode space, and plasma is not generated in the bottom space of a lower electrode stage.

Therefore, it becomes possible to prevent the membrane formation to the bottom space of a lower electrode stage, etc.

[0045]Since the insulator ring 58 is formed like the above-mentioned, it can reduce that a film adheres to the inner surface which the reaction vessel 11 exposes in a membrane formation process. This reason is explained in full detail next.

[0046]Drawing 3 is a figure for explaining the reason for the above. (A) shows selectively the position relation between the insulator ring 58 and the membrane formation space 81 formed as a narrow space by drawing 3, and (B) shows the grade of the film adhesion by the Z direction of the reaction vessel 11 at the time of membrane formation in the state where the insulator ring 58 was formed. A Z direction is shown by drawing 3 (A) and, as for drawing 3 (B), it shows the thickness (a unit is angstrom \*\*) in which the distance (a unit is cm) of a Z direction and a vertical axis adhere to the internal surface of the reaction vessel 11 in a horizontal axis. If a membrane formation process is performed when the distance D between the upper electrode 13 and the lower electrode 14 is 2 cm and membrane formation space is a narrow space, as shown in drawing 3 (A), so that it may be clarified in drawing 3 (B), In respect of the paries medialis orbitae

of the reaction vessel 11, a film adheres in the thickness about about  $10^{-4}$  from the undersurface of the upper electrode 14 to lower [ about about 2-cm ], and membranous coating weight decreases greatly among 2 to 3 cm, and it becomes about 10A from the undersurface of the upper electrode 14 in the place of about about 3 cm. Therefore, when the cleaning process of the inner surface of the subsequent reaction vessel 11 is taken into consideration, it is desirable to cover with the insulator ring 58 from the undersurface of the upper electrode 14 to about about 3-cm part.

[0047]Next, a cleaning process is explained. Step cleaning is performed in the cleaning in the reaction vessel 11. Step cleaning is a cleaning process gradually extended with plasma space to the passage of time, and is a cleaning method which comprises several steps from which conditions differ. In step cleaning, at the time of a cleaning start, the lower electrode 14 goes up, and is in the position at the time of a membrane formation process, and plasma space is narrowed. For this reason, in cleaning of this state, high-frequency power can be concentrated on the two electrodes of the upper electrode 13 and the lower electrode 14 which the film has deposited most thickly. Then, cleaning of as opposed to each wall surface for the large space currently formed at some of upper electrodes 13, lower electrodes 14, and reaction vessels 11 is performed by dropping the lower electrode 14 gradually (step target). In the culmination of step cleaning, the lower electrode 14 descends to the position of substrate transportation, and cleaning of the head of the lift pin which has projected from the stage surface in which this carries the substrate 12 of the lower electrode 14 is performed.

[0048]More specifically, it comprises the 1st to 3rd step preferably. The interval of the upper electrode 13 and the lower electrode 14 is a narrow space, and the 1st step is performed in the state of the high density plasma formed in the high power field of VHF band high frequency, and the 2nd step, The lower electrode 14 is dropped from the undersurface (principal surface) of the lower electrode 14 to the undersurface of the insulating material ring 58, It is carried out only by the high density plasma formed in the high power field of VHF band high frequency by this state, and cleaning is performed with the low density plasma in which the 3rd step is dropped to the lowest and forms the lower electrode 14 in the low-electric-power field of VHF band high frequency. When generating plasma using the high frequency of a VHF band, it is also possible by adjusting electric power to adjust the density of plasma.

[0049]In the 1st step and the 2nd step, since the inner surface of the reaction vessel 11 is covered with the insulator ring 58, it can clean by high density plasma. In the 3rd step, since the inner surface of the reaction vessel 11 appears and the reaction vessel 11 is made from the aluminum alloy, it is made to clean with low density plasma.

[0050]The density of the high density plasma in the 1st step and the 2nd step is about  $1E11\text{-cm}^{-3}$  in the above-mentioned cleaning method, and the density of the low density plasma in the 3rd step is about  $1E10\text{-cm}^{-3}$ .

[0051]In the above-mentioned step cleaning, it can set arbitrarily according to a device according to the purpose about to the number of steps or what kind of timing step descent is performed.

[0052]At this embodiment, high density plasma is generated by the high frequency (typically 60 MHz) of the VHF band supplied from RF generator 32. By making excitation frequency of plasma high, high order dissociation of cleaning gas is promoting because \*\*\*\*\* which can make plasma density high

usually makes plasma density high according to this embodiment. As a result, F radical quantity effective in etching of an oxide film can be increased.

[0053]In the reaction vessel 11 of the large-sized plasma CVD device concerning this embodiment, RF generator 32 which supplies the 3-kW high frequency for plasma excitation at 60 MHz is carried instead of conventional 13.56 MHz. The low frequency power source 33 for the bias application process in 400 kHz is also incorporated for the purpose of improvement in the etch rate of the oxide film by an ion bombardment. That is, in this embodiment, in order to aim at stable transmission of high frequency, a 400-kHz low frequency wave is superimposed on the above-mentioned high frequency, and it is being impressed by the upper electrode 13.

[0054]In the above-mentioned plasma CVD device, since membranes are formed by making space between the upper electrode 13 and the lower electrode 14 into a narrow space, the homogeneity in membrane formation is securable. In order to secure the homogeneity in narrow space membrane formation, precision improvement of the equipment component is planned. that the point which generally forms membranes uniformly on the surface of the substrate 12 generates uniform plasma, and making the homogeneous good gas density distribution on the lower electrode 14 -- it comes out. In this viewpoint, the plasma CVD device by this embodiment has the feature of the following point.

[0055]Homogeneous good gas density distribution is formed on the stage of the lower electrode 14. This plasma CVD device is also performing gas supply through the shower part provided in the upper electrode 13. The 1st factor that determines the gas density distribution homogeneity on the lower electrode 14 is in the arrangement of the shower hole of a shower part. The electrode spacing is setting distance between shower holes to 4 mm preferably in order to enable uniform gas molecule supply at least 1 cm.

[0056]The 2nd factor that determines the homogeneity of gas density distribution is making a gas stream symmetrical on the lower electrode 14, and uniform generate. Therefore, the narrow path 71 which sets to 5 mm between the flank of the lower electrode 14 and the insulator rings 58 provided in the wall of the reaction vessel 11 is formed. By forming this narrow path 71, the gas flow conductance of the narrow path concerned becomes small. Therefore, the gas flow in the inter-electrode space of the upper electrode 13 and the lower electrode 14 becomes difficult to be influenced by the conductance distribution in the lower part of the reaction vessel 11. In spite of being the side exhaust air which established the exhaust port in the reaction vessel wall of the lower electrode 14 bottom as the result, a gas flow with sufficient symmetry can be obtained in inter-electrode space.

[0057]It explains that the gas in a membrane formation process flows. Based on the above-mentioned viewpoint, the state where the flow of gas was simulated only about the case with an electrode spacing [ at the time of a membrane formation process ] of 1 cm is shown in drawing 4. The result at the time of using Ar gas as gas first is shown. The pressure in an exhaust port is fixed with 300 Pa, and the result of having changed the gas mass flow introduced from the shower part of the upper electrode 13 with 500sccm, and having simulated it is shown. By the interval of the narrow path 71 being 5 mm preferably shows that the gas flow without an eddy etc. is obtained like the above-mentioned so that clearly from this simulation.

[0058]Since both the upper electrode 13 and the lower electrode 14 are made from pure aluminium beyond  $1E-4$  in the above, the corrosion by F radical becomes small.

[0059]If the electric field in the surfaces, such as the upper electrode 13, the lower electrode 14, and an

insulator, is strengthened using HF-bands high frequency (bias application), cleaning speed can make it increase by the effect of ion kinetic energy in the 1st step of the above.

[0060]As a concrete example, when forming silicon oxide,  $\text{SiH}_4$ ,  $\text{N}_2\text{O}$ , and diluted Ar are used as process gas, and conditions with a pressure of 300 Pa and a substrate temperature of 300 \*\* are set up. When forming a silicon nitride film,  $\text{SiH}_4$ ,  $\text{NH}_3$ , and  $\text{N}_2$  are used as process gas, and conditions with a pressure of 300 Pa and a substrate temperature of 300 \*\* are set up. As a cleaning process,  $\text{C}_2\text{F}_6$  (perphloro carbon) and  $\text{O}_2$  are used and cleaning speed increases by the above-mentioned step cleaning.

[0061]

[Effect of the Invention]By the above explanation, according to this invention, the following effect is done so so that clearly.

[0062]Having adopted step cleaning in the cleaning process with the large-sized plasma-CVD processing unit etc. For example, a sake, the utilization efficiency of cleaning gas is raised -- things can be carried out, an exhaust gas amount can be reduced by this, cleaning speed can be raised, productivity can be made good, the amount of the process gas used can be reduced, and process cost can be reduced. Since high-density plasma cleaning can raise dissociation of  $\text{C}_2\text{F}_6$  in the 1st step and the 2nd step especially, the amount used can be reduced and it can be made useful for solution of a global warming issue. Since it was made to cover with an insulator ring from the principal surface of the upper electrode of game membrane formation to prescribed distance, the film coating weight to the inner surface in a film forming chamber can be reduced.

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[Translation done.]